Forecast the impact of change in a manufacturing environment

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Abstract: - This paper presents a new methodology to forecast the results of changes in a manufacturing environment using a web based application and expert systems. The solution presented in this paper represents a good option for shifting the balance of change management from being reactive to being proactive. The process and application described here will enable the production manager to increase predictability, to optimize the processes, to use the resources better, to evaluate new workflows or technologies and to plan for future upgrades. By using expert system with specific industry templates, ChangeXpert will offer managers a detailed change report describing the impact of changes in their manufacturing process. This paper investigates changes impact in the manufacturing environment and introduces a methodology which allows for better planning.


1 Introduction

A change is defined as anything – hardware, software, machines, robots, system components, services, people, documents, or processes – that is deliberately introduced into the production environment and which may affect the functioning of the environment or one of its components.[1]

For most companies, manufacturing changes begin when an issue is identified on the manufacturing process or when the product design is changed.

The problem that managers are facing is the difficulty to manage a growing complexity, to accurately forecast the impact of their changes or to evaluate various options in advance.[2] To ensure that changes are effectively implemented across internal and external teams, it is important to develop solid manufacturing change processes. Without such a process, production management consists of a never-ending series of ad-hoc, undocumented and unplanned changes.

Over time various methods have been developed in manufacturing industries to help managers predict the results of their decisions. Currently, most companies are using spreadsheet templates to evaluate the changes in their processes and only few organizations have implemented so called Business Intelligence (BI) ERP applications to create scenarios and to make decisions. There are a number of disadvantages in ERP systems for manufacturing: difficulty to precisely model the manufacturing process, impossibility to describe interdependencies between variables and more important, the ERP systems do not learn from experience.

To satisfy those needs, the authors have developed a web based application using expert system. This application allows the users to precisely model their organisation and define specific rules of interaction between all parameters. They combined the power of expert system with a user friendly web application.

Based on extensive experience in manufacturing industry, information from research and statistics, an expert knowledge database has been created for the manufacturing industry (Change management plan template). This database enables the user to focus on any impact of its change, use the best practices and make educated decisions based on complete analysis of change input and output.

2 Objectives and application area

The objectives of this paper are to present the research conducted on change management tools and to show the author's contribution in developing
a compressive solution to forecast the impact of change in a manufacturing environment. Changes can be divided into 4 categories: [3]

A. Scheduled Change: this can be characterised as a change which is new (has not previously been performed), therefore we must investigate and plan accordingly. B. Emergency Change: this is the process we invoke when something has broken (a major component of the production system is no longer available) and, hence, we do not have the privilege of planning the change. In this case, rather than creating and reviewing a plan prior to execution, fixing the problem must be our first priority. C. Procedurised Change: those tasks which occur more than once can and should be turned into procedures.D. Automated Change: those procedures which, by their nature, we execute many times over can be automated to improve consistency and reduce execution overhead.

The methodology presented in this paper is used for Scheduled Change in the manufacturing environment. Here we have strategic changes and complex relations, difficult to accurately forecast. Examples of this kind of changes are: reconfiguring workflows, increasing the production capacity by adding new CNC machines, replacing people with robots, adopting a new production control system for the plant, implementing a software solution for Product Lifecycle Management or Total Quality Management.

3. Solution development

When a manager is planning a change he will pay attention to total cost, total cycle time, delivery performance, quality and safety. These metrics have multiple connexions. Factories have thousands, perhaps millions of variables moving around at the same time and every event has multiple drivers. Actions taken to optimize one variable often come at the expense of another. That's why performance metrics are probably the most important element of manufacturing management.

In this chapter we will describe how a manager can structure all the information and how this can be used to forecast the impact of the change.

3.1 Knowledge acquisition and structure

Having good and relevant information is a critical aspect of the expert system effort. To be able to make a smart change initiative a manager needs: 1. Focus on the most important variables of the environment.[5] 2. Audit and understanding of the current situation. 3. Forecast with good accuracy the impact of changes.

Any initiative of change management should begin with a systematic diagnosis of the current situation in order to determine both the need for change and the capability to change. [4] The objectives, content and process of change should all be specified as part of a Change Management plan.

Implementing a change in a production environment is a team work and it is absolutely necessary to consider three major factors: People, Processes and Technology. To create a comprehensive analysis of a change, the manager should interview all the colleagues affected by that initiative. He should know the key metrics and capture the values during interviews. As described in fig.2, the inference engine is using 4 sources of information to forecast the impact of a change: 1. Knowledge from Database - this represents all the experience stored in industry templates. 2. Knowledge from change agent - this usually contains the objectives and the structure of the change. 3. Knowledge from external sources - this could represent costs of the changes or data from interviews. 4. Feedback from the user interfaces - these are updates made the managers based on estimated results.

3.2 Technology used

Having in mind the user's needs the application was developed on web AWS EC2 architecture.
This is available from the cloud and the customer can access the application from any device, from any location and no installation is required. The application architecture is presented in Fig.1. The Amazon Services have multiple advantages: Resizable Compute Capacity (as much as you need, when you need it), scale up or down, complete control via API Create, scale & manage instances programmatically, variety of instance sizes CPU power, cores, RAM, disk, wide variety of pre-built AMIs (Amazon Machine Images).

ChangeXpert is developed to accumulate experience and become a better adviser. The application is using expert system algorithms to process information and rules.

Expert system, by definition, is a computer program that simulates the thought process of a human expert to solve complex decision problems in a specific domain. An expert system operates as an interactive system that responds to questions, asks for clarification, makes recommendations and generally aids the decision-making process.

Expert system provide expert advice and guidance and can help the decision maker to evaluate different options. Expert system represent a revolutionary transition from the traditional data processing to knowledge processing. Expert system offer an environment where the good capabilities of humans and the power of computers can be incorporated to overcome many of the limitations discussed in the previous chapters.

Expert system have numerous advantages:
1. Increase the probability, frequency and consistency of making good decisions 2. Help distribute human expertise 3. Facilitate real-time, low-cost expert-level decisions by the non-expert.
4. Enhance the utilization of most of the available data. 5. Permit objectivity by weighing evidence without bias and without regard for the user’s personal and emotional reactions. 6. Permit dynamism through modularity of structure. 7. Free up the mind and time of the human expert to enable him or her to concentrate on more creative activities. 8. Encourage investigations into the subtle areas of a problem. Fig.1 present the structure of the application and information workflows.

In order to be easily accessible from anywhere, from different computers or internet browsers, ChangeXpert was developed using Microsoft SilverLight technology. This makes the application available from the cloud and no installation is needed.

3.3 ChangeXpert application description

ChangeXpert is a solution designed to be used by consultants, managers or sales teams who are working for a technology initiative to identify the potential benefits of a change and support better decisions.

Its main aim is to help the decision makers evaluate the impact of changes and compare different implementation plans. In the end the application automates the creation of a detailed Return on Investment business case to be presented and obtain budget approval. ChangeXpert is an online software product which offers an easy-to-use tool automating complex calculations and providing credibility by allowing users to audit figures by viewing interactive charts and see the changes impact dynamically. It offers the managers a flexible way of modelling the internal structure of their departments and company, with their specific workflow. ChangeXpert further helps managers to model the cost of emerging changes and to make better decisions. ChangeXpert allows users to rapidly create projects for specific industries, using templates that are stored in an online repository which is used to start the workflow process. The first step in the workflow is entering some basic information about the project, time and its business structure. The second step is to build the change by adding the costs structure, recurring costs and change timeline in ChangeBuilder. Using a specific industry template, the manager can introduce the specific knowledge in ChangeBenefits (Fig.3 organisation chart, departments, operations, costs,
management data, information from interviews, rules of interaction). This is followed by automatic calculation of the change cost/benefit using the supplied information and data from the expert system knowledge database.

The software process ends with an automated production of a Business Case, a report stating the cost, benefits and the ROI measures timeline for the solution. The business case is then used by the manager for better decision making.

![ChangeXpert interface](image)

**Fig.3 ChangeXpert interface**

CX Templates - represent preconfigured projects for different industries, organizations or departments. For manufacturing environment the template includes standard operations collections and allows the manager to add the costs (tooling, prototype build/test, searching and accessing data, interruptions, scrap and re-work, time saving rules, overtime, warranty, manual data re-entry, bill of materials management, quality, safety, design re-use, prove-out. The CX Report represents an interactive interface that enables the end user to see the impact of changes in his environment. It has the option to create multiple implementation scenarios and compare the results in the same graphic chart. After the comparison, the selected scenario will be exported in a Return on Investment Business Case. This document contains all the details for decision support and change approval.

**4 Conclusion**

Change management is crucial to survive in a rapid changing environment. Decision making is difficult within a complex organisation where all the variables are interdependent. In order to manage this complexity and to support better decisions, a general framework was introduced in this paper. An interactive application for change management process, incorporating industry knowledge, customer needs and requirements into the planning phase, can help any company increase quality and meet time-to-market objectives by keeping unwanted or unauthorized changes out of the product lifecycle.

Manufacturing today is distributed around the world, knowledge for decision makers should be available everywhere, therefore, a move to a virtual environment and a web based application is a major benefit for production managers.

New generations of developers need new features for successful work in global teams. This process can be significantly accelerated by appropriate education, training and management. Independent individuals who know what they can expect from a global development team and are familiar with communication technologies will become involved in such teams with optimism and trust. ChangeXpert is offering support for smarter decisions and better change plans. The application is perfectly scalable and can be developed in the future to guide decisions in different organizations or industries. The template database is open and any user can contribute with a new domain.

**References:**


